Mapping grey ghosts in Appalachian hollows using dormant-season change

InVEST Workshop

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"The map's the thing"

We need a <u>baseline</u> map of eastern and Carolina hemlock.

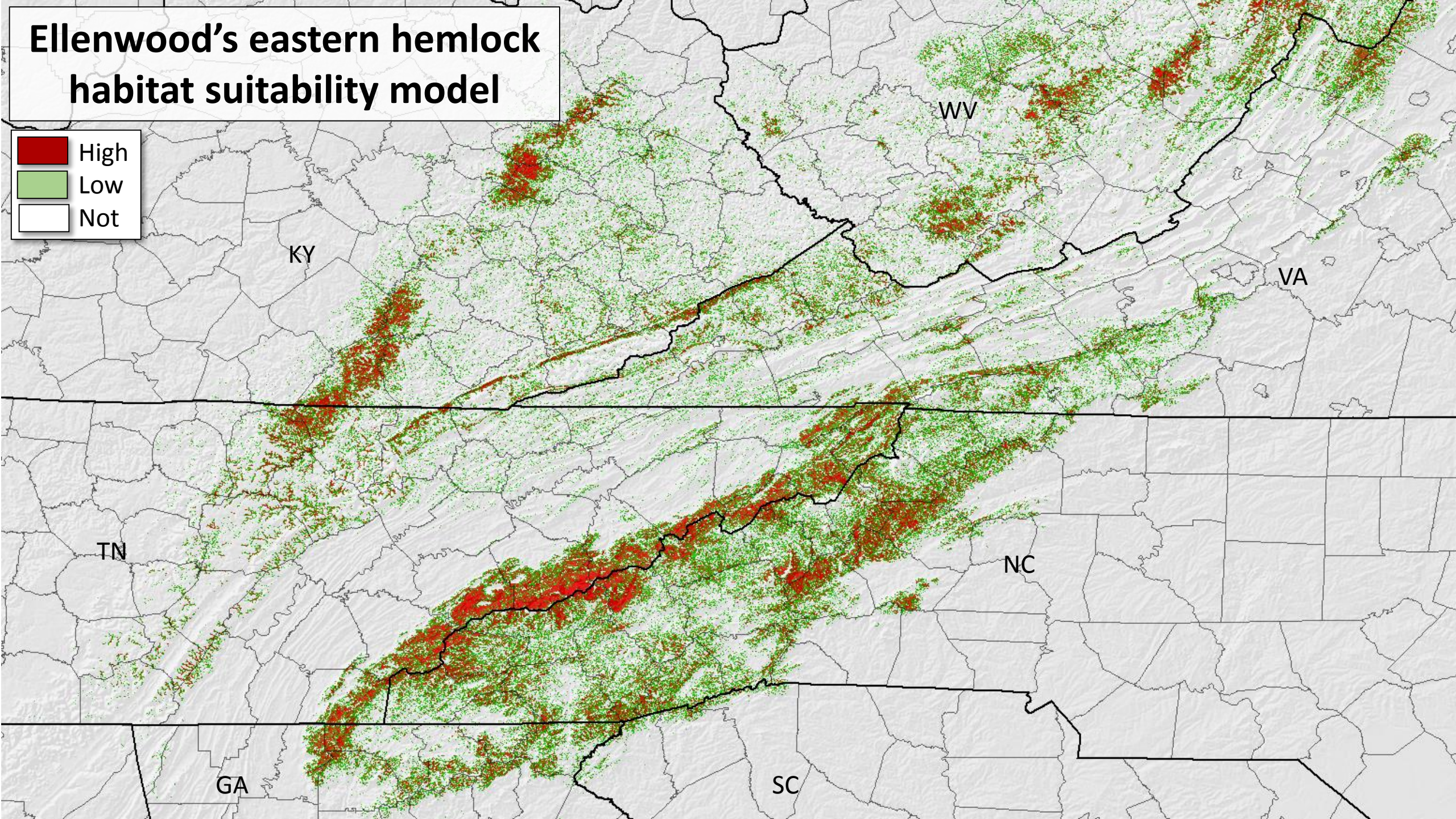
- Species habitat suitability models exist (shows potential).
- Mapped vegetation types (e.g., Northern Hardwood) are coarse, but show known community associates.
- Hard-to-model forest history and chance affects actual occurrence.

We need a map of hemlock <u>decline</u> and <u>mortality</u>.

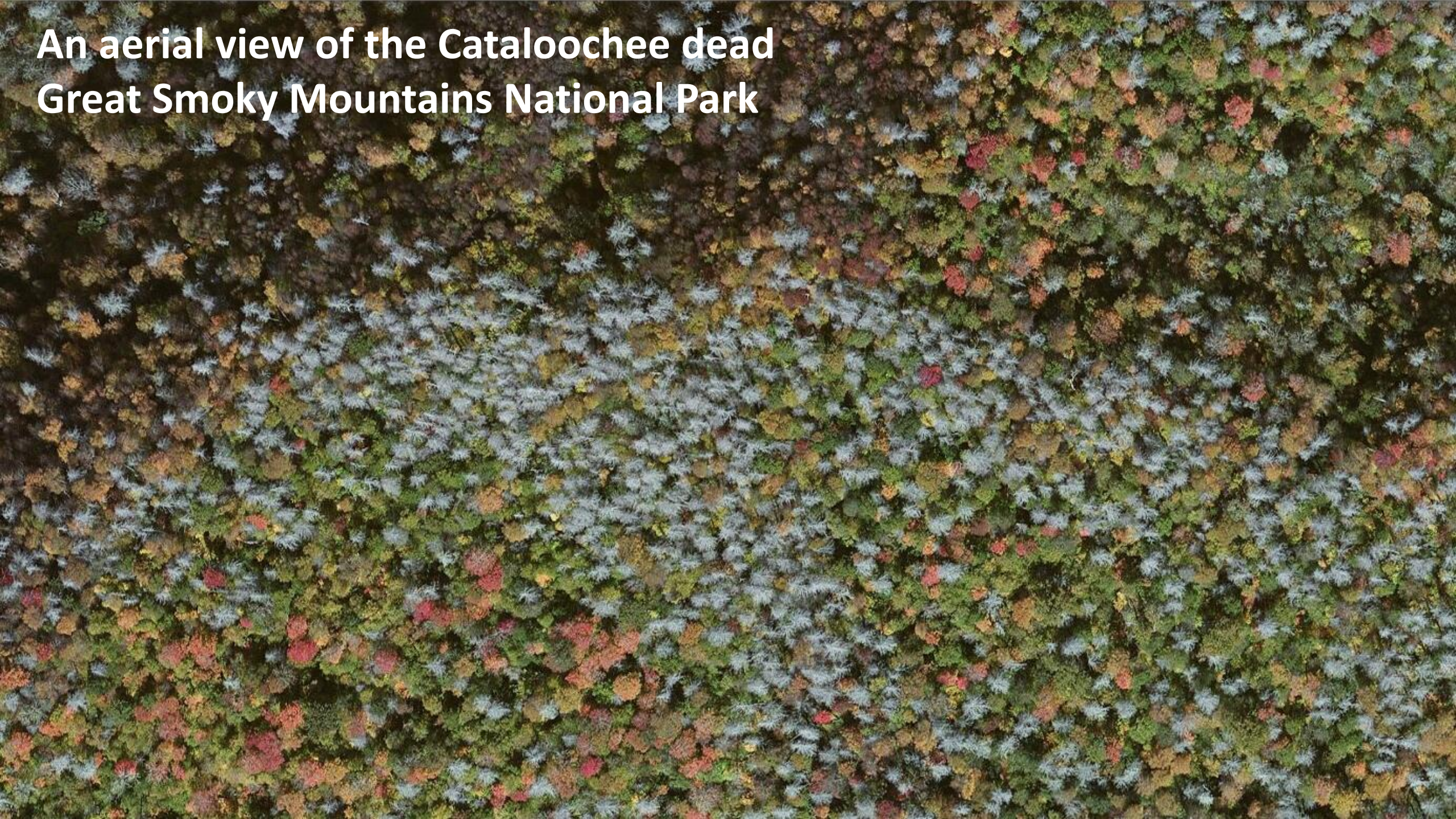
- Are dead hemlock the best indicator of hemlock's actual distribution?
- Other disturbances obscure adelgid impacts (e.g., fire).
- Compensatory response of neighbors obscures (esp. growing season).
- Dormant season evergreen monitoring has challenges too.

We need maps of <u>impacts</u> to effectively prioritize or mitigate

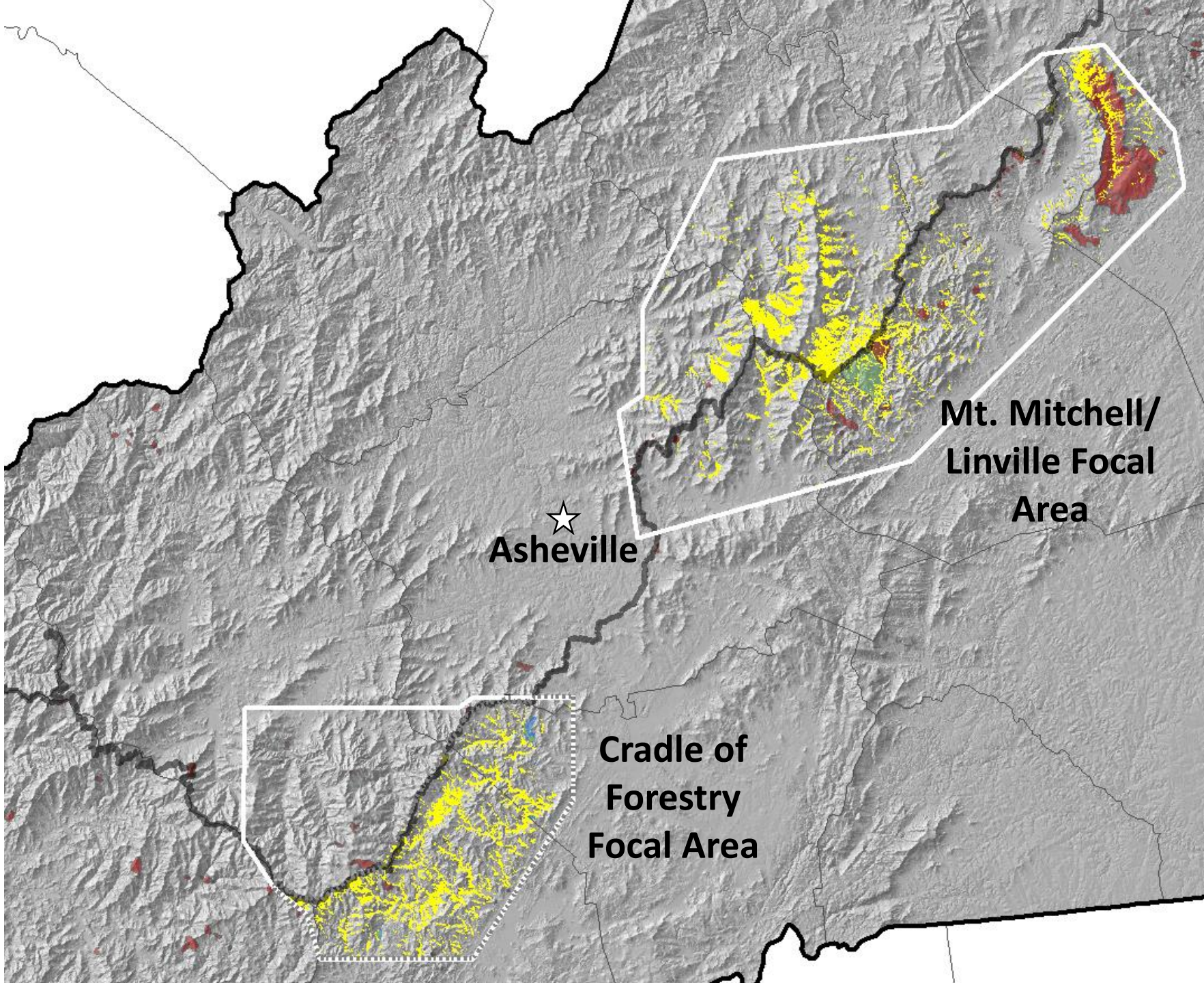
- This involves modeling (e.g., associated spp., fire and fuels, hydrology)


Ellenwood's eastern hemlock habitat suitability model
High
Low
Not
KY
WV
VA
TN
NC
GA
SC

Dead hemlock in Linville Gorge

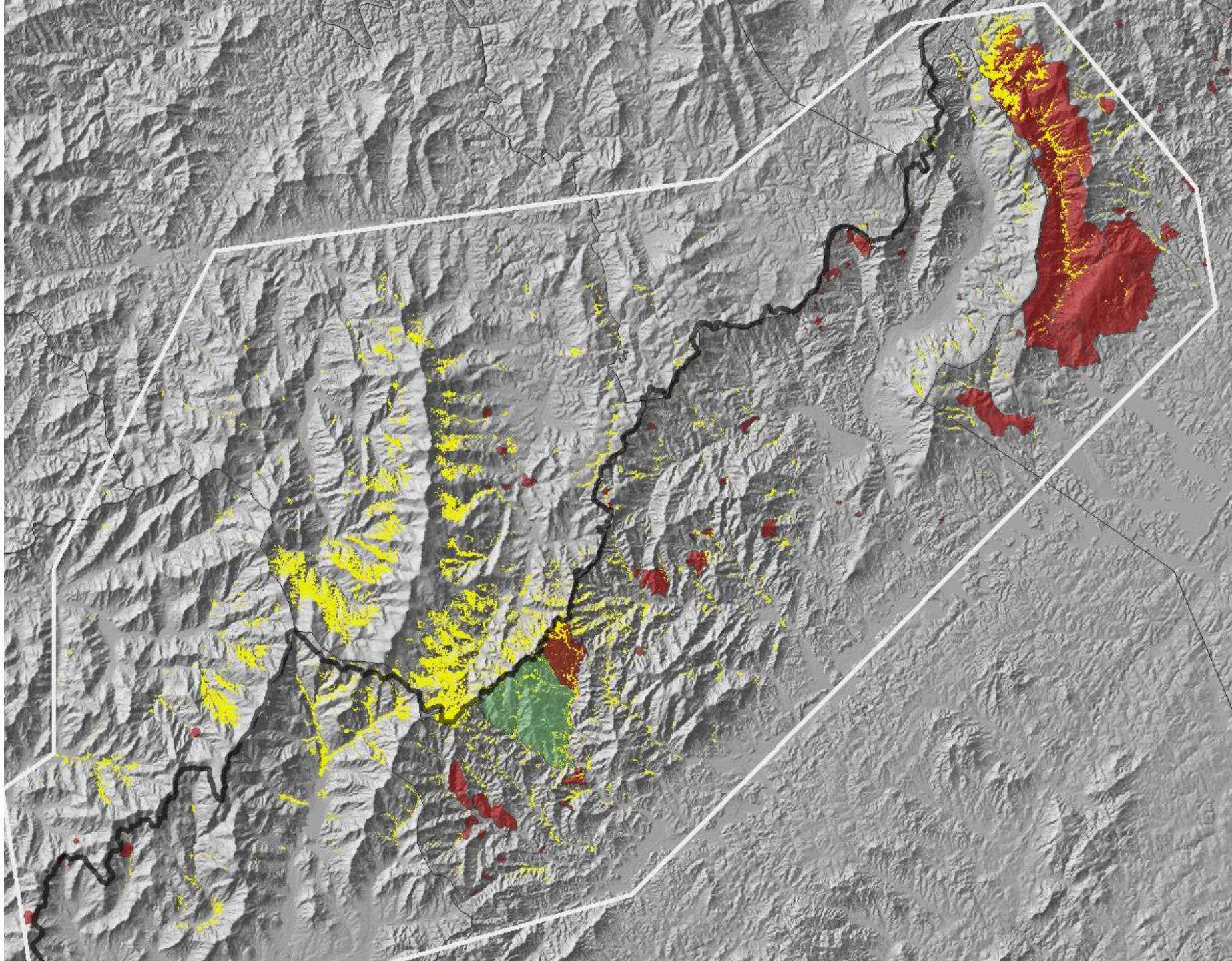

An aerial view of the Cataloochee dead
Great Smoky Mountains National Park

Digitized canopy dead from 2010 aerial imagery



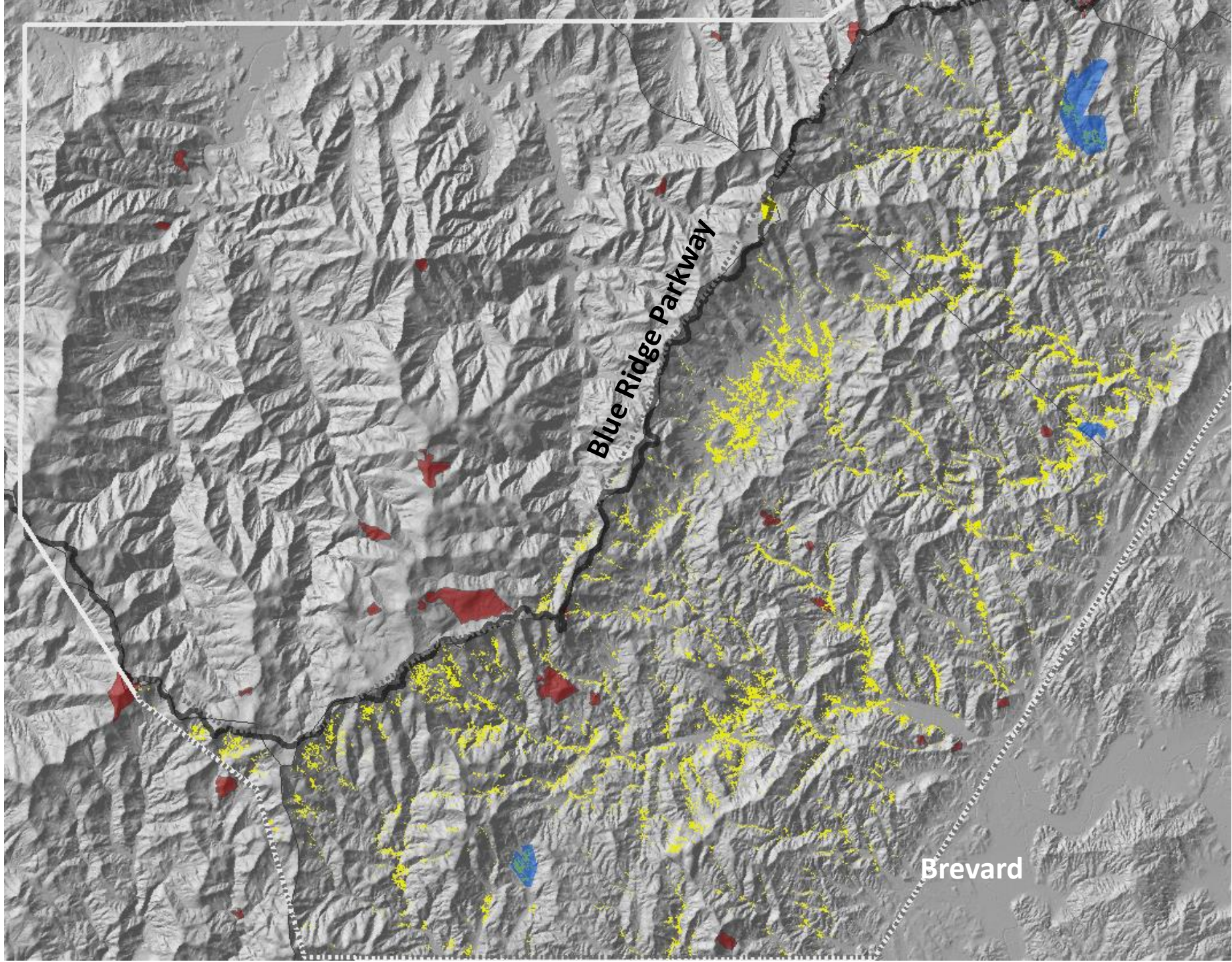
Digitized canopy dead from 2010 aerial imagery

Mt. Mitchell/ Linville Gorge focal area showing fires



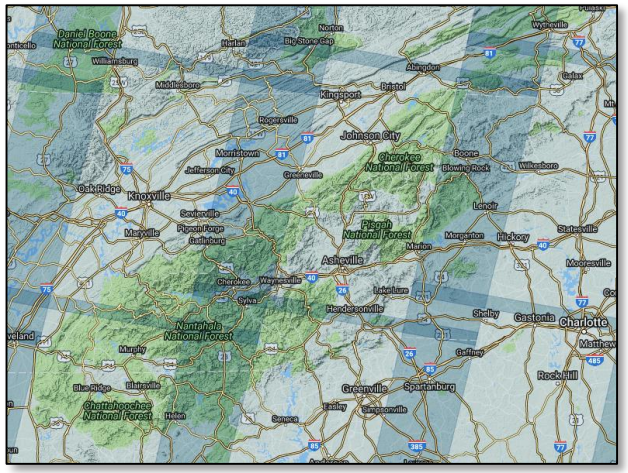
Digitized canopy dead from 2010 aerial imagery

Cradle of Forestry focal area showing fires



Systematic landscape monitoring

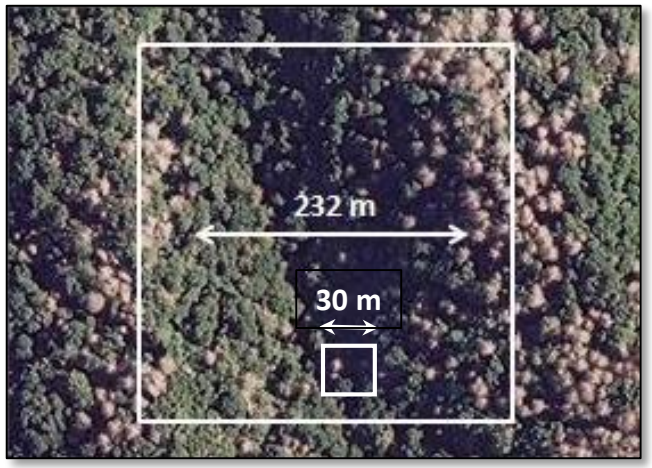
- Given the region's cloud cover and phenological dynamics, we need frequent looks for precise interpretations.
- But higher frequency leaves us with satellites having coarser resolution (e.g., MODIS, AVHRR)



Landsat tiles for the Southern Appalachians

The *ForWarn* dataset

- Based on daily MODIS satellite streams
- Highly processed (maximum value compositing, interpolation, smoothing)
- 232m spatial resolution (13.4 ac.)
- 8-day time steps (46 periods per year)
- NDVI (Normalized Difference Vegetation Index)
- Data online at ORNL's DAAC and viewable at *forwarn.forestthreats.org*

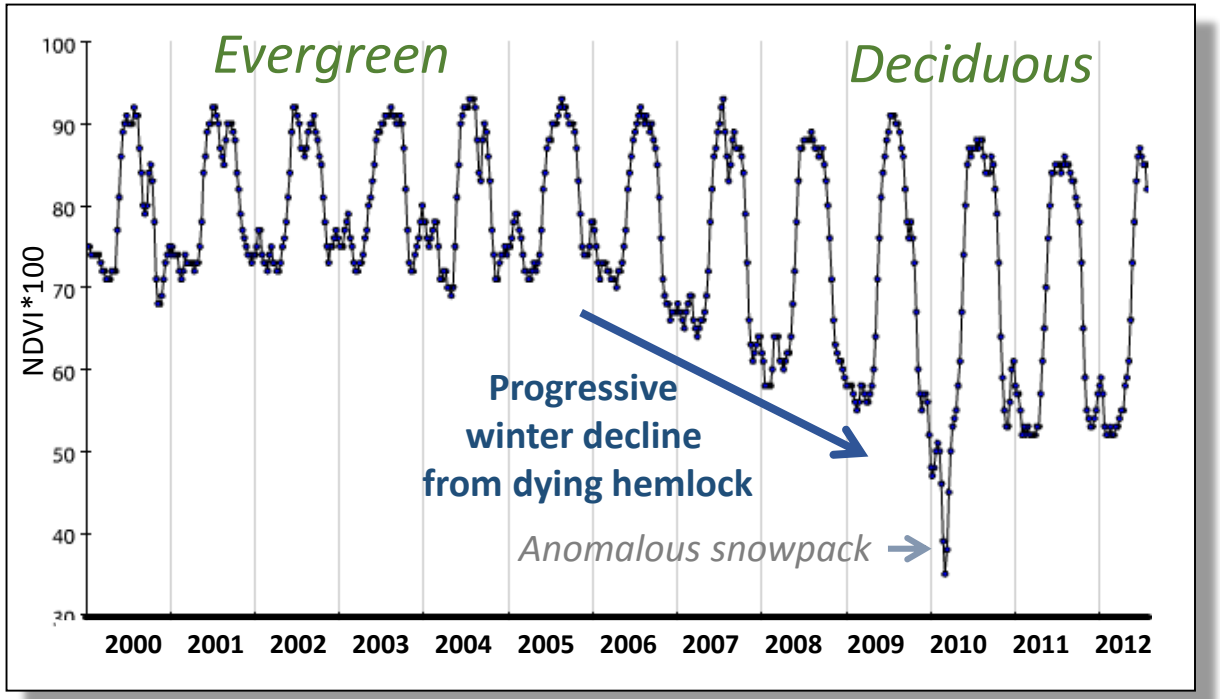


A comparison of Landsat and MODIS grid cell resolution

Disturbances exhibit different "signatures" in MODIS time series

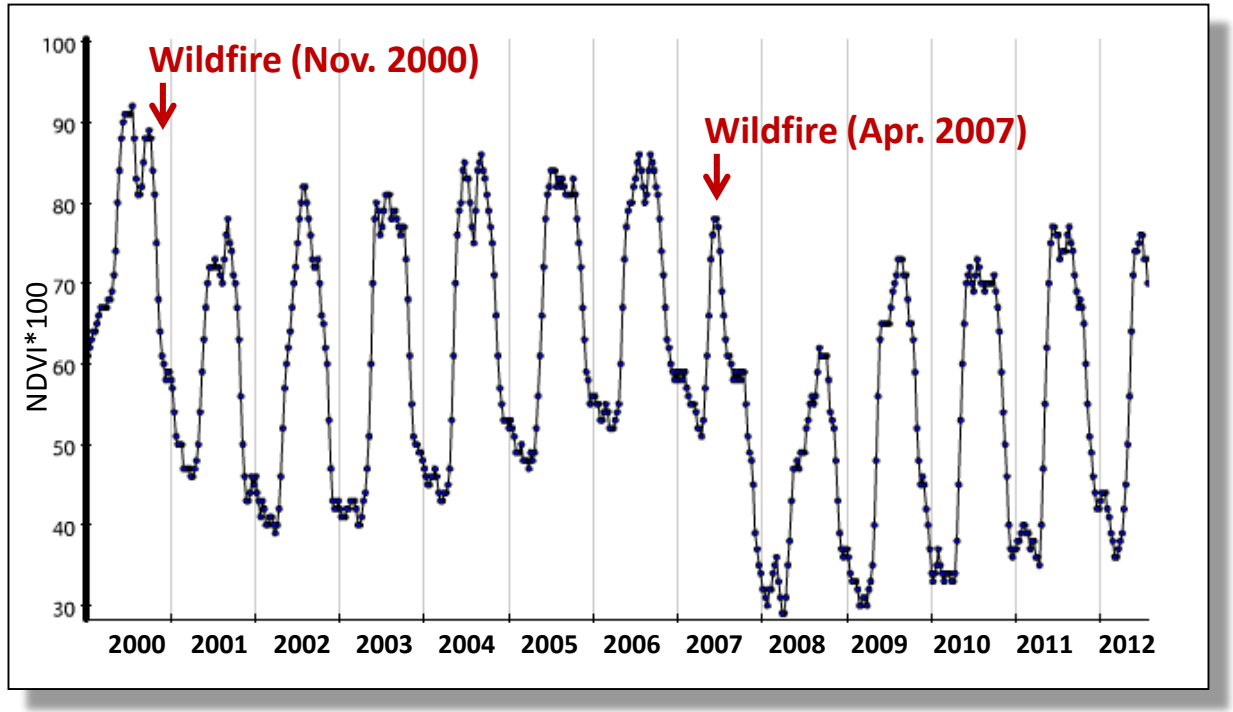
MODIS NDVI signature of Hemlock Woolly Adelgid decline

Pisgah NF near Mt. Mitchell



MODIS NDVI signature of a sudden disturbances (e.g., fire)

Linville Gorge Wilderness, Pisgah NF

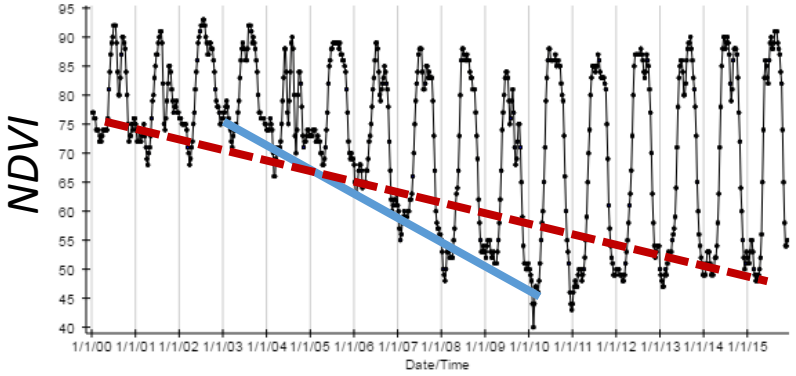


Modeling evergreen decline

- Tracking change in dormant season NDVI avoids the compensatory deciduous responses of summer *and* captures understory evergreen change.
- *But* winter NDVI is more challenging due to deciduous leaf retention, snow pack, variable cold temperature effects on semi-evergreenness, and strong shadows (esp. on north slopes and in coves where hemlock thrived).

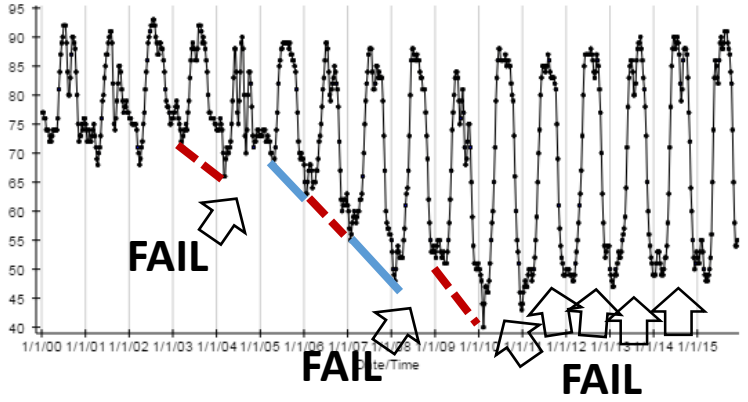
MODELS

1. Annual trend



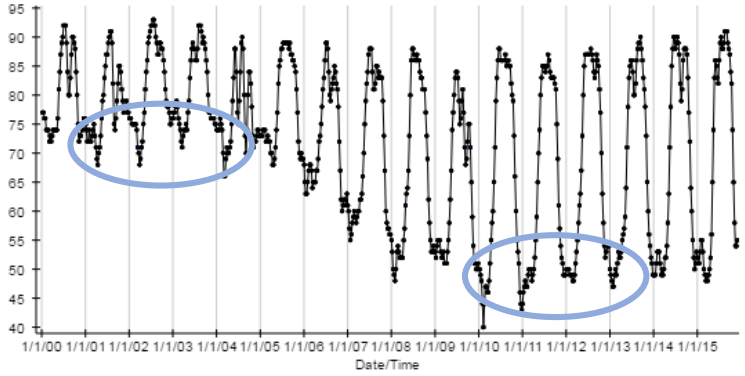
Slope as the measure of severity depends on cover loss AND start/end dates.

2. Stepped decline (rule-based)



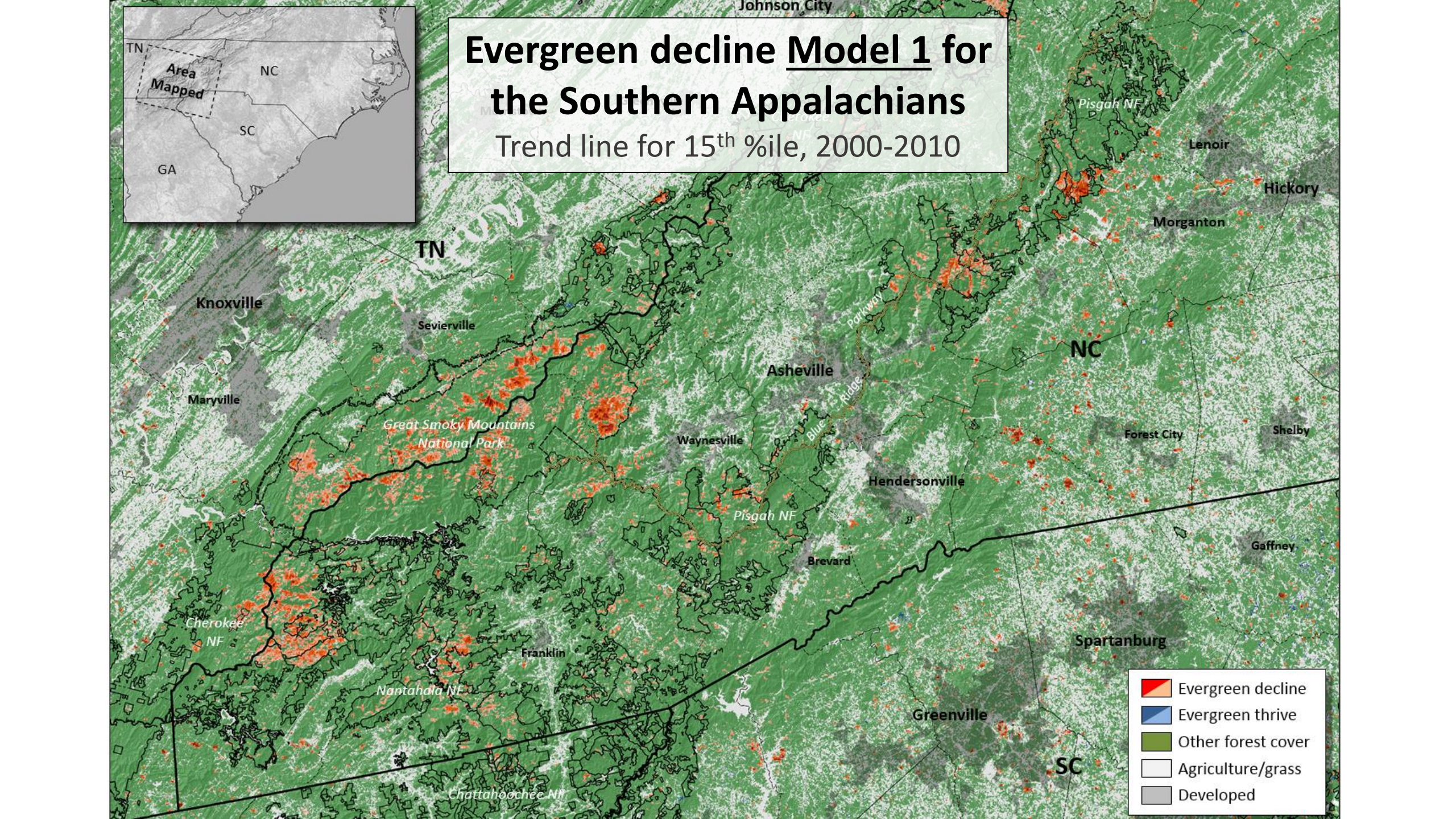
Severity is annual NDVI decline.

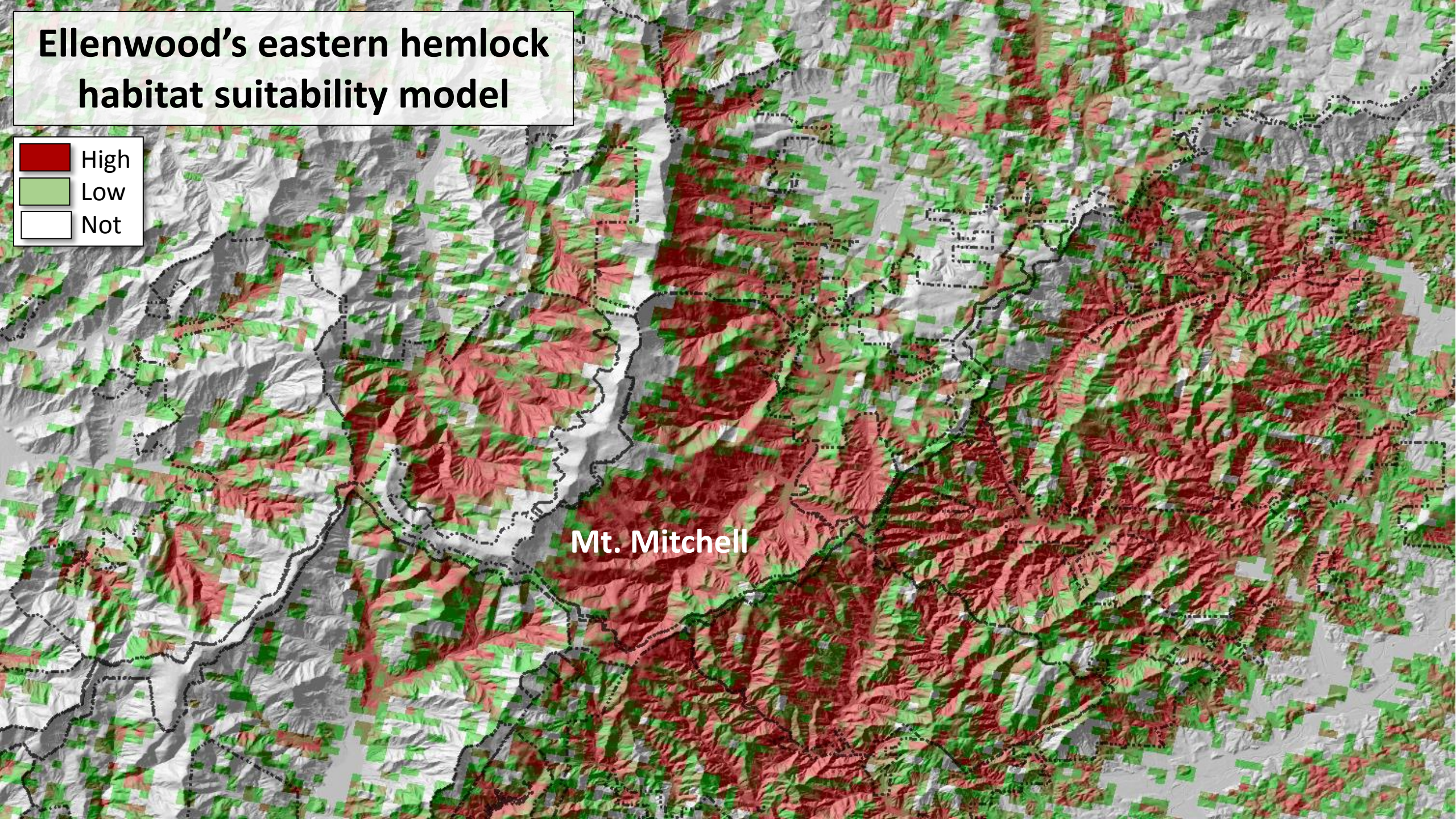
3. Start vs. end state



Severity is era NDVI decline.

ADDITIONAL DECISIONS: Use the winter min., winter max, or some lower percentile of the annual NDVI distribution?


Evergreen decline Model 1 for the Southern Appalachians
Trend line for 15th %ile, 2000-2010
TN
Area Mapped
NC
SC
GA
Johnson City
Pisgah NF
Lenoir
Hickory
Morganton
TN
Knoxville
Sevierville
Parkway
NC
Asheville
Maryville
Great Smoky Mountains National Park
Blue Ridge
Waynesville
Forest City
Shelby
Hendersonville
Pisgah NF
Gaffney
Brevard
Cherokee NF
Franklin
Spartanburg
Nantahala NF
Greenville
SC
Chattahoochee NF
Evergreen decline
Evergreen thrive
Other forest cover
Agriculture/grass
Developed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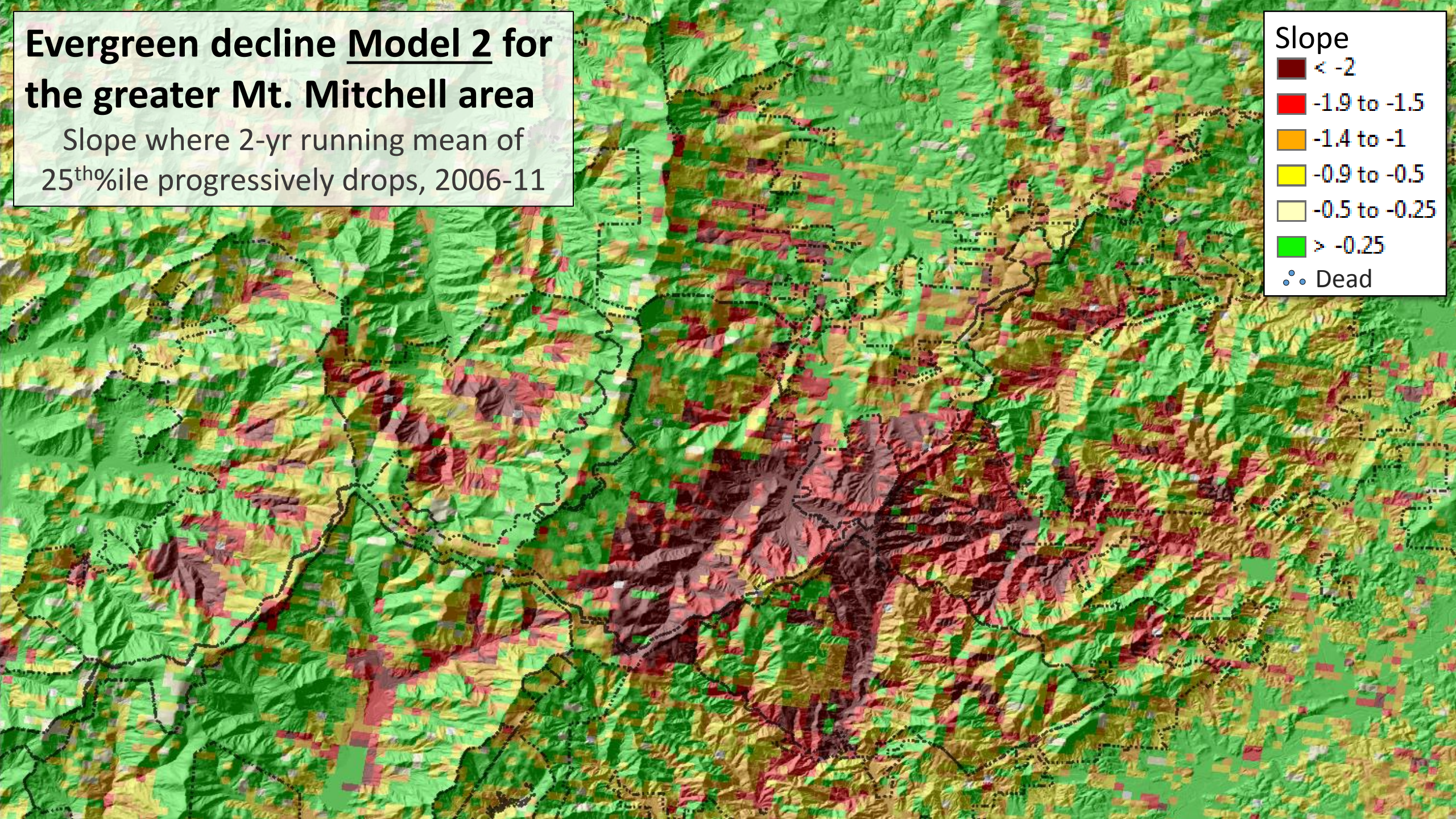
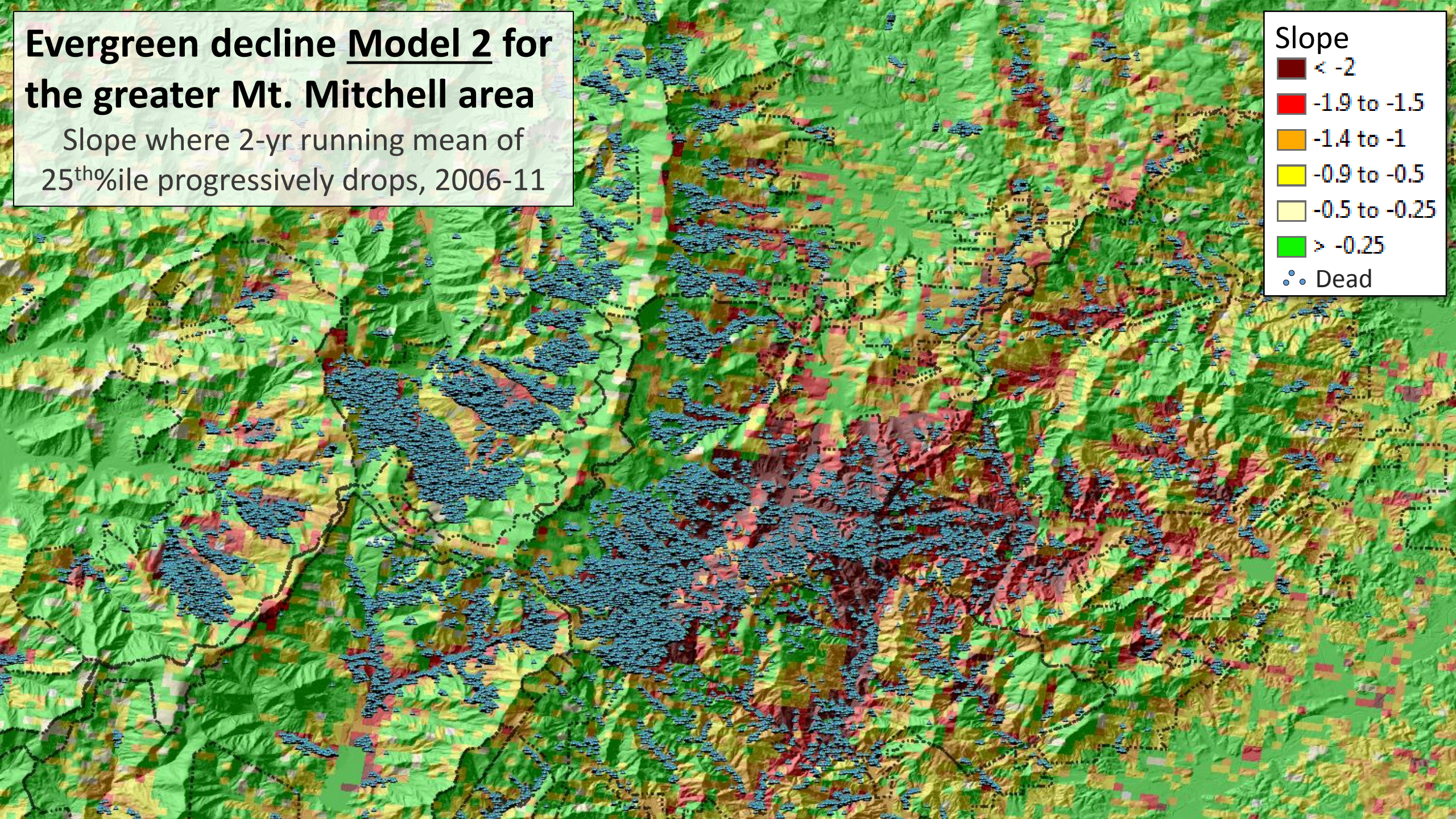

Evergreen decline Model 2 for the greater Mt. Mitchell area
Slope where 2-yr running mean of 25thpercentile progressively drops, 2006-11
Slope
< -2
-1.9 to -1.5
-1.4 to -1
-0.9 to -0.5
-0.5 to -0.25
> -0.25
Dead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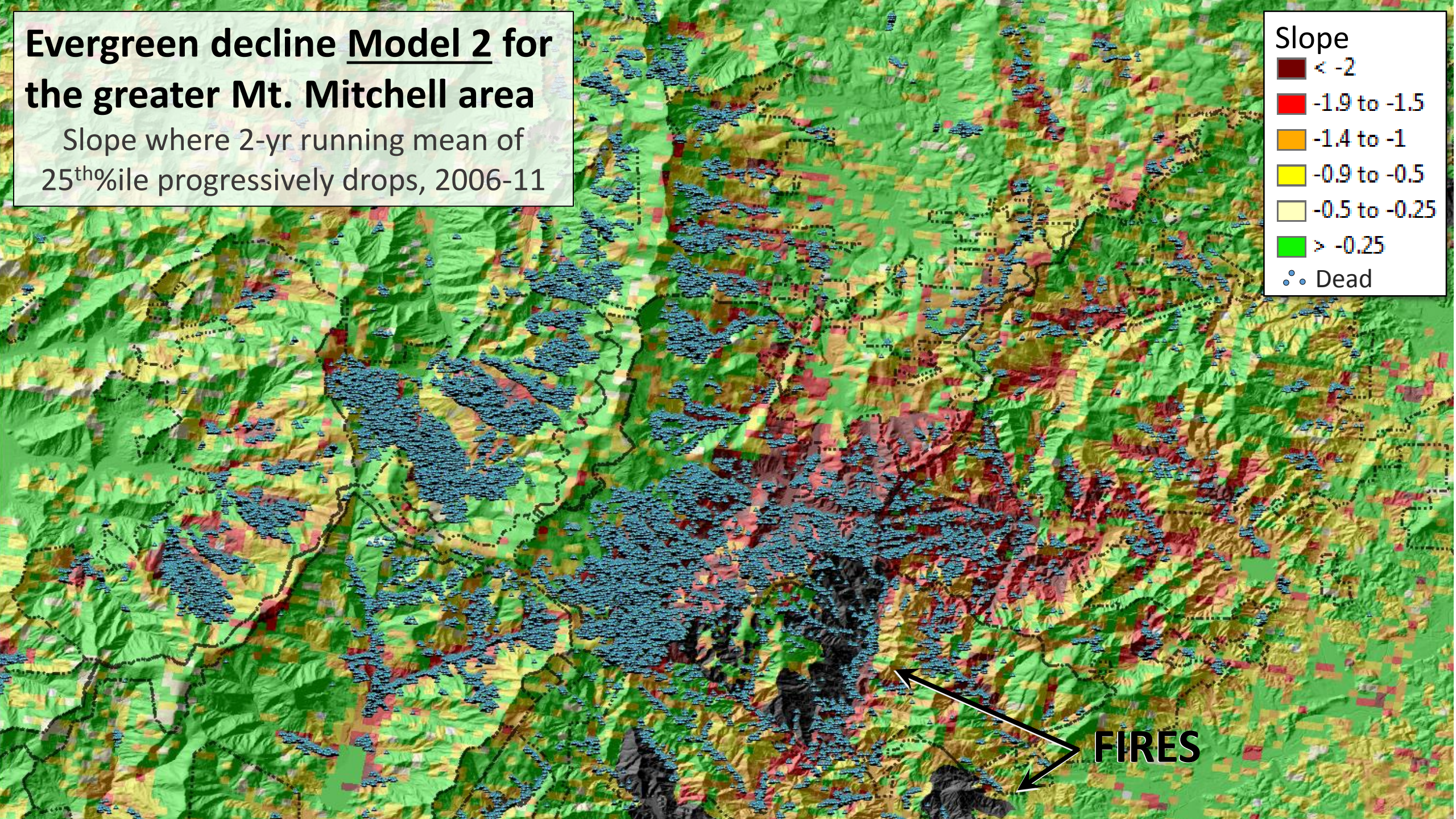
Dead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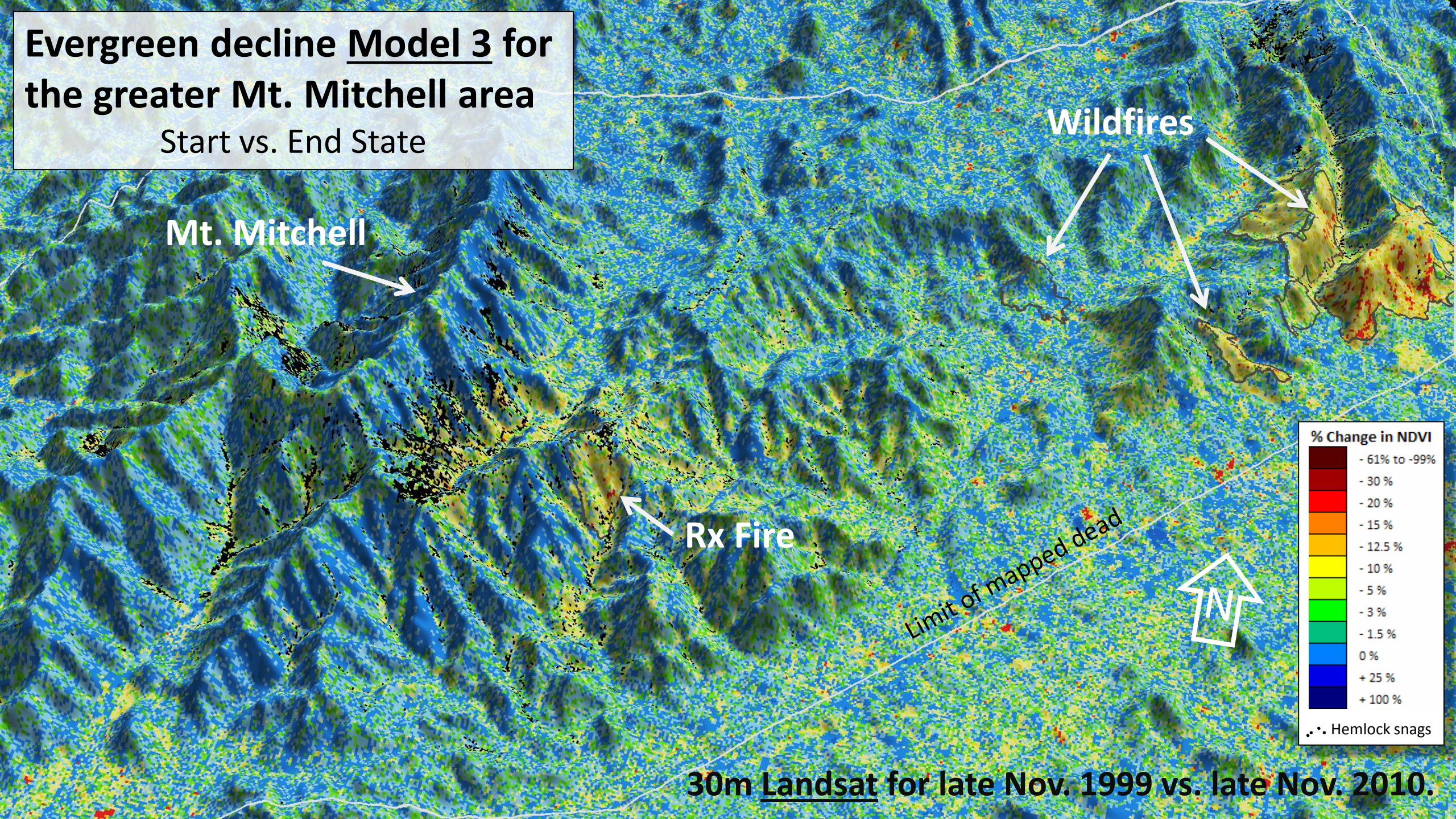
-0.9 to -0.5
-0.5 to -0.25
> -0.25
Dead
FIRES

Evergreen decline Model 3 for the greater Mt. Mitchell area

Start vs. End State



30m Landsat for late Nov. 1999 vs. late Nov. 2010.

Possible explanations for surprisingly extensive areas of evergreen decline

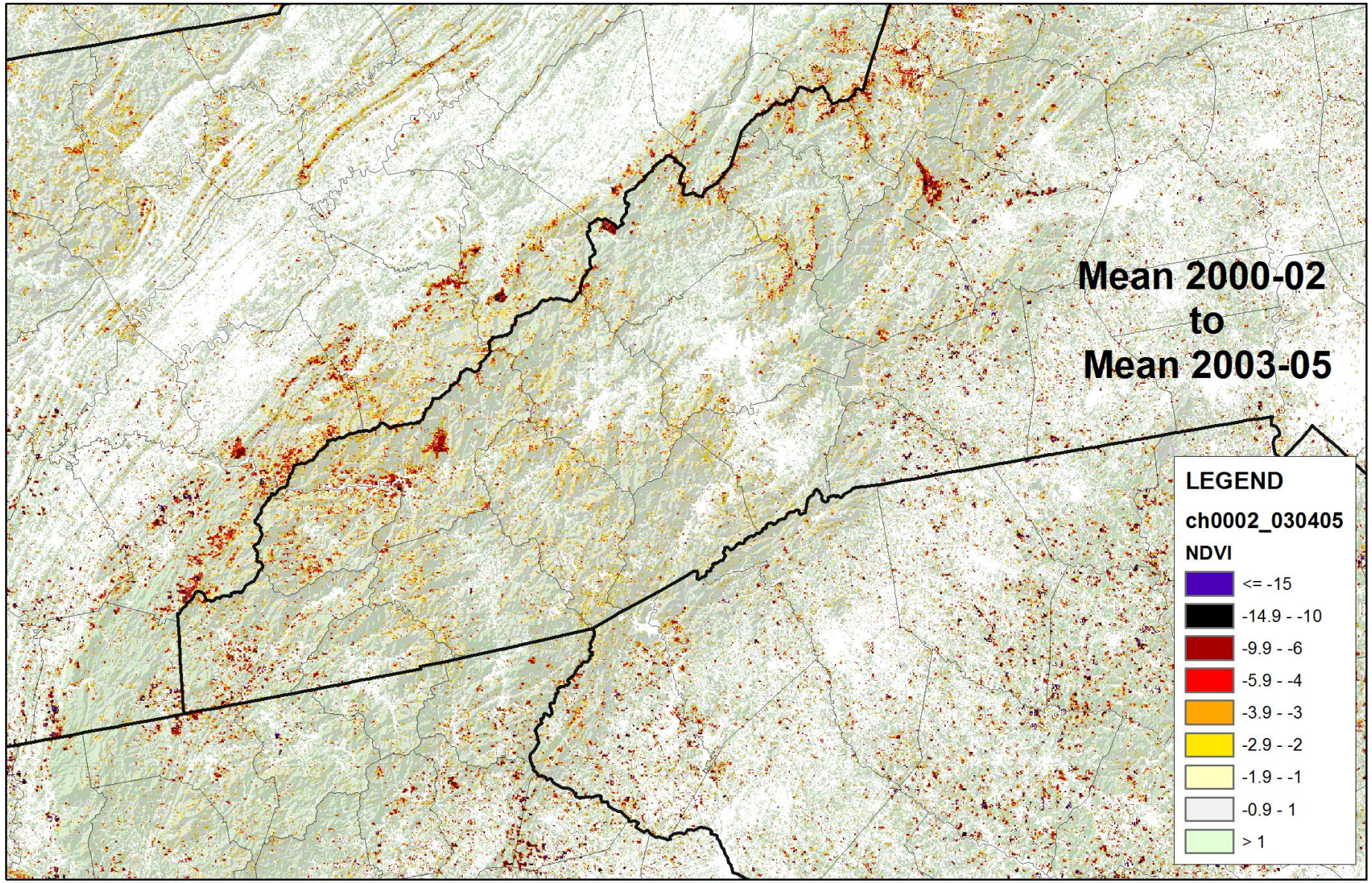
1. It is “phantom decline” caused by some methodological artifact.
2. “Non-target” species are also in decline.

   (*e.g.*, Rhododendron dieback, pine decline)

3. It <u>is</u> hemlock decline, but (unmapped) sub-canopy trees and saplings.
   - Most sites of decline are “known” hemlock habitat or are adjacent to mapped dead hemlock canopy trees
   - Eastern hemlock are slow growing and shade tolerant; they spread to new areas with forest mesophication

Evergreen Forests of the Southern Appalachians and Neighboring Regions

Using ForWarn's Maximum Winter (Jan. - Mar. 5) NDVI



Feb. 2016 SPN

The 2000-02 average winter maximum is the baseline.

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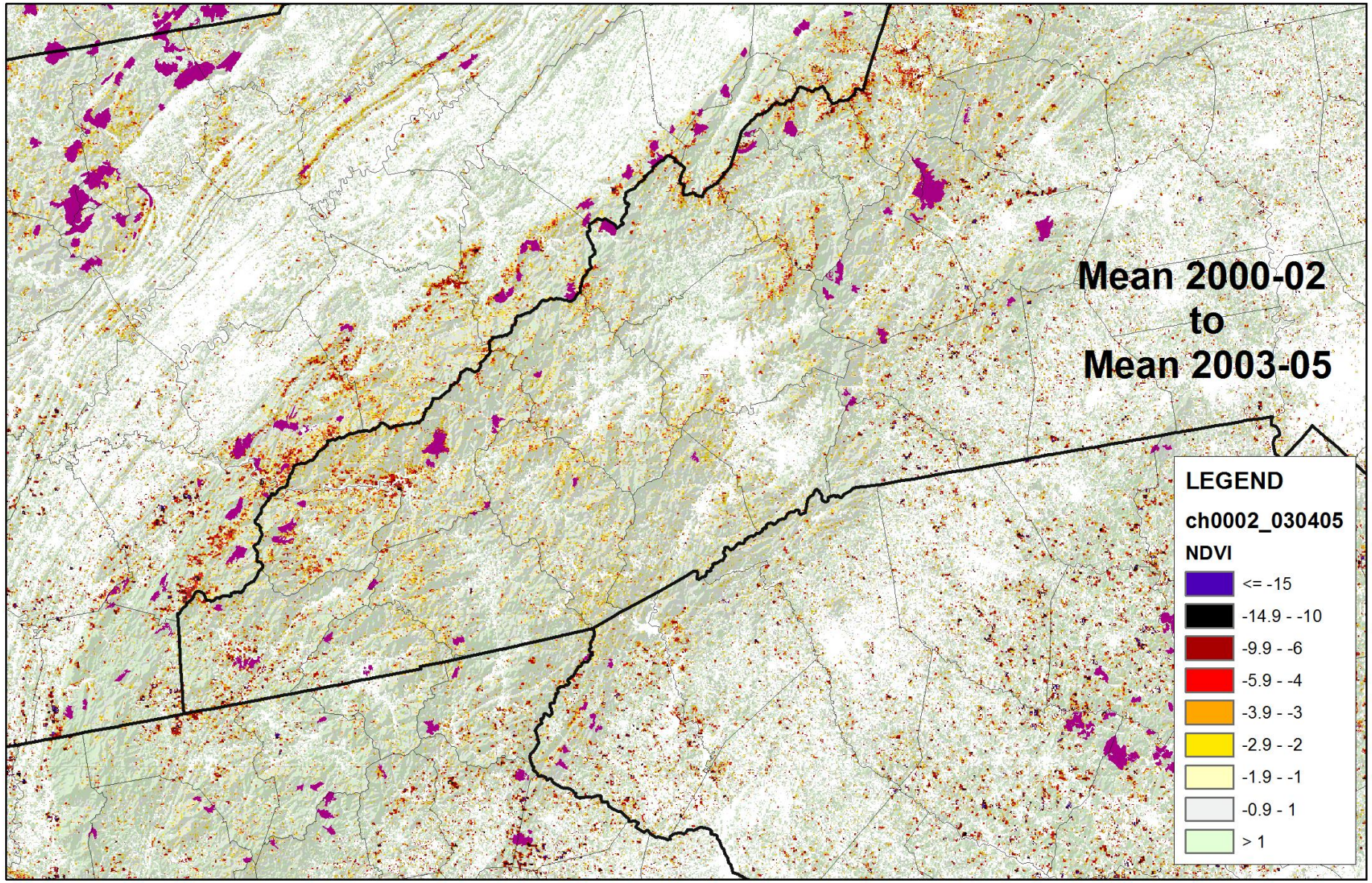

Much decline from fire, but some HWA.

The 2000-02 average winter maximum is the baseline.

Feb. 2016 SPN

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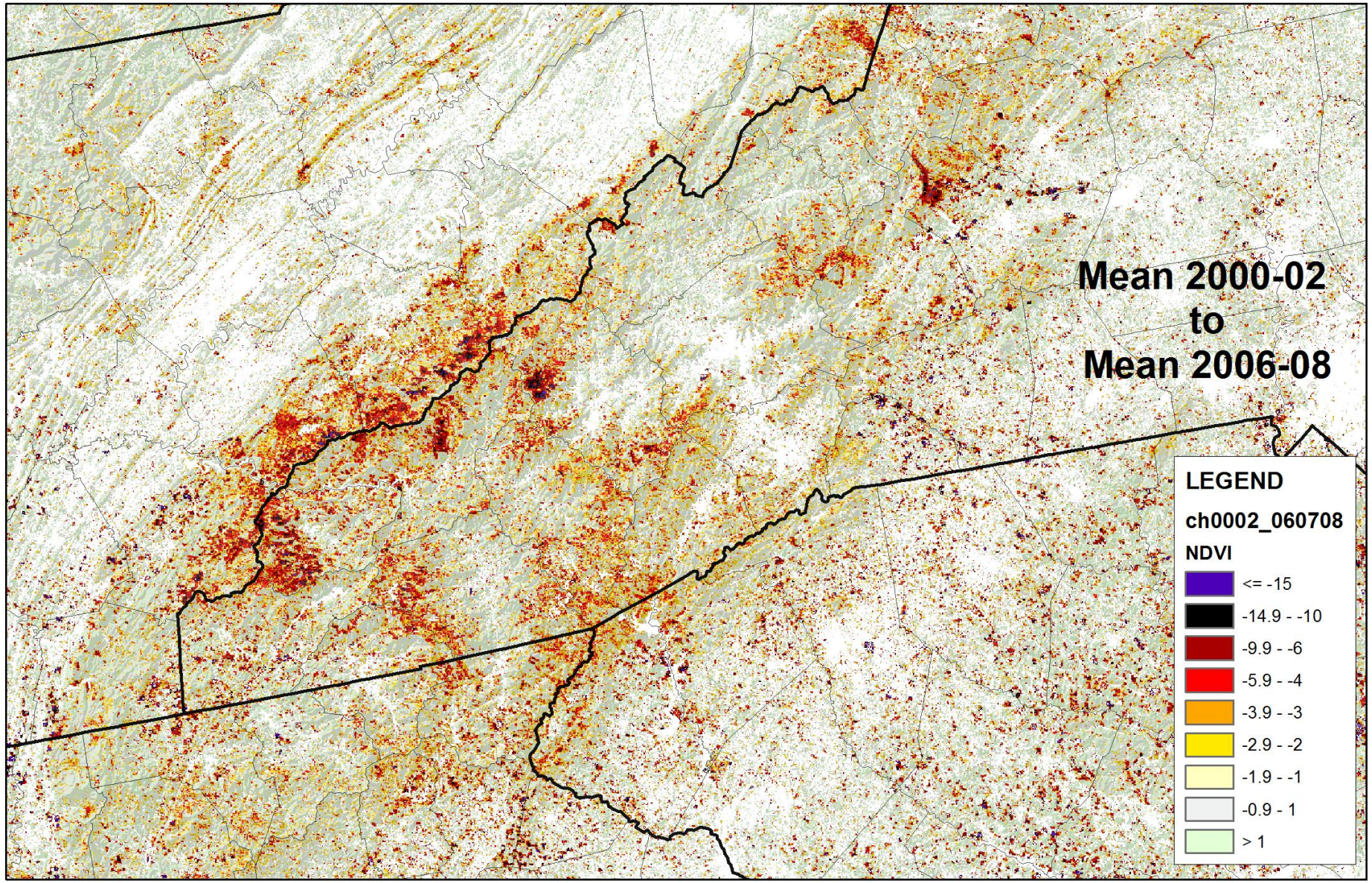

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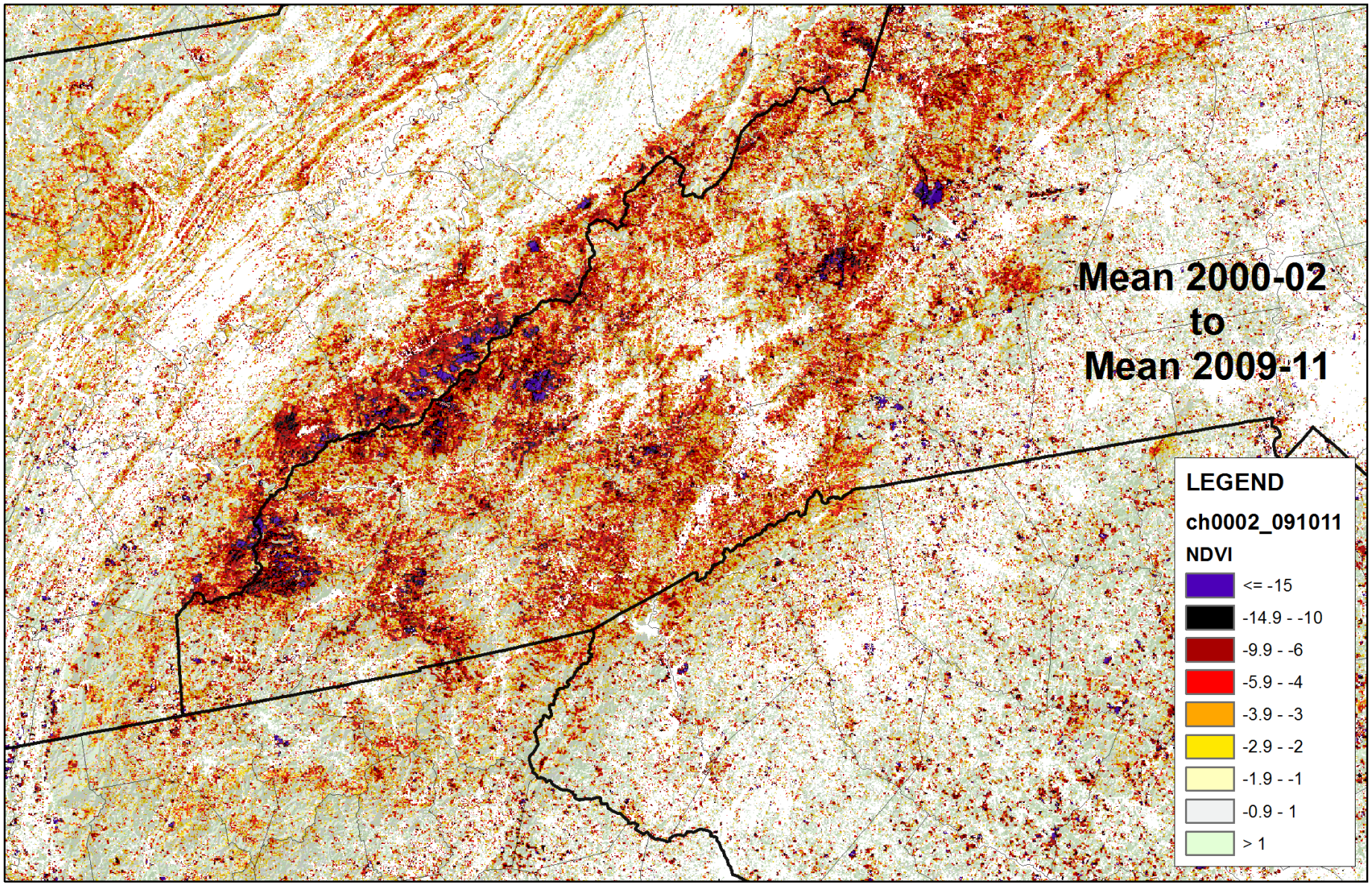
Evergreen Forests of the Southern Appalachians and Neighboring Regions

Using ForWarn's Maximum Winter (Jan. - Mar. 5) NDVI

Likely over-estimated due to unusual winter weather.

The 2000-02 average winter maximum is the baseline.



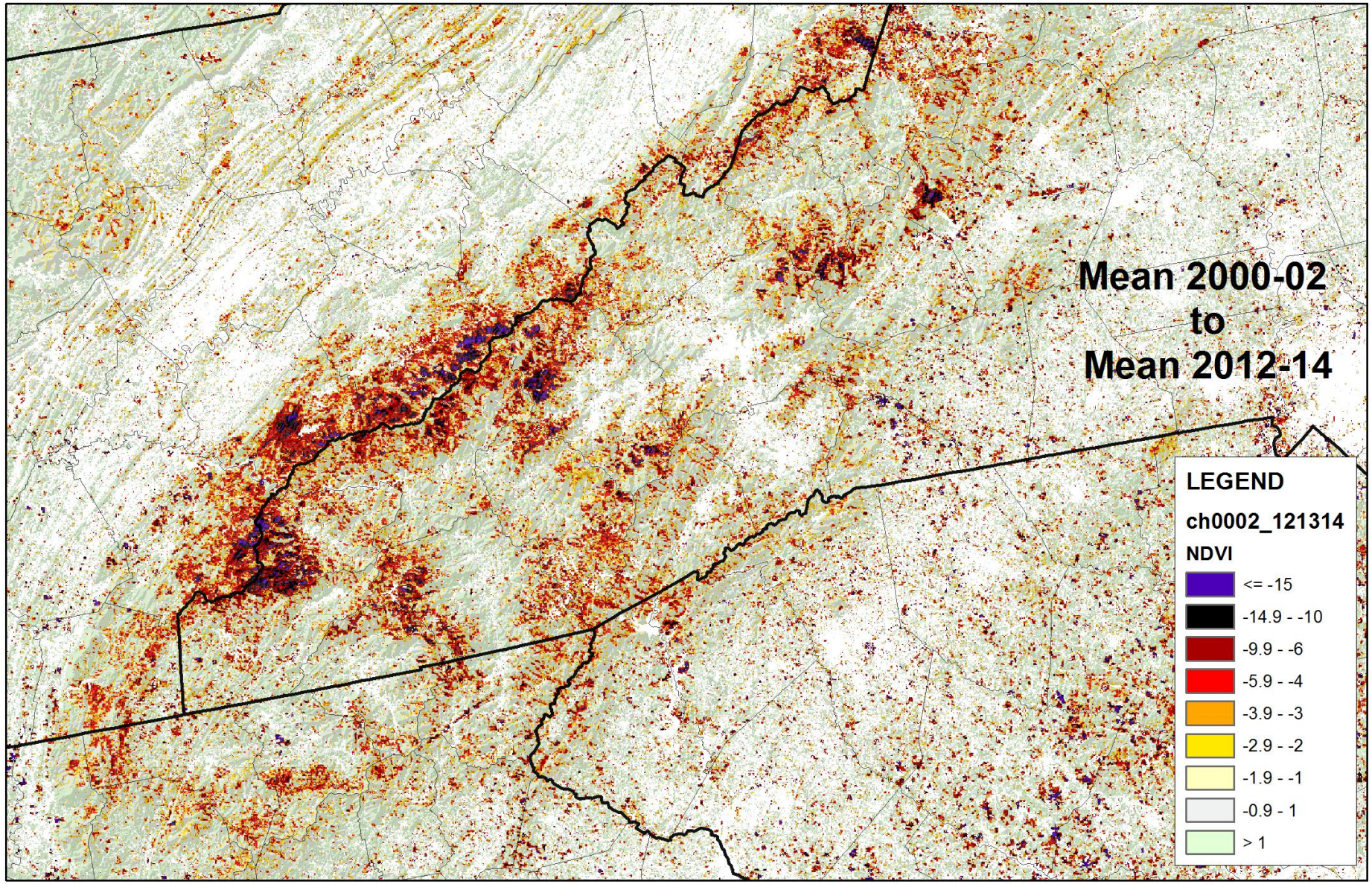
Feb. 2016 SPN

Evergreen Forests of the Southern Appalachians and Neighboring Regions

Using ForWarn's Maximum Winter (Jan. - Mar. 5) NDVI

Note progression of HWA impacts toward the southwest and the tornado in northeast GA.

The 2000-02 average winter maximum is the baseline.



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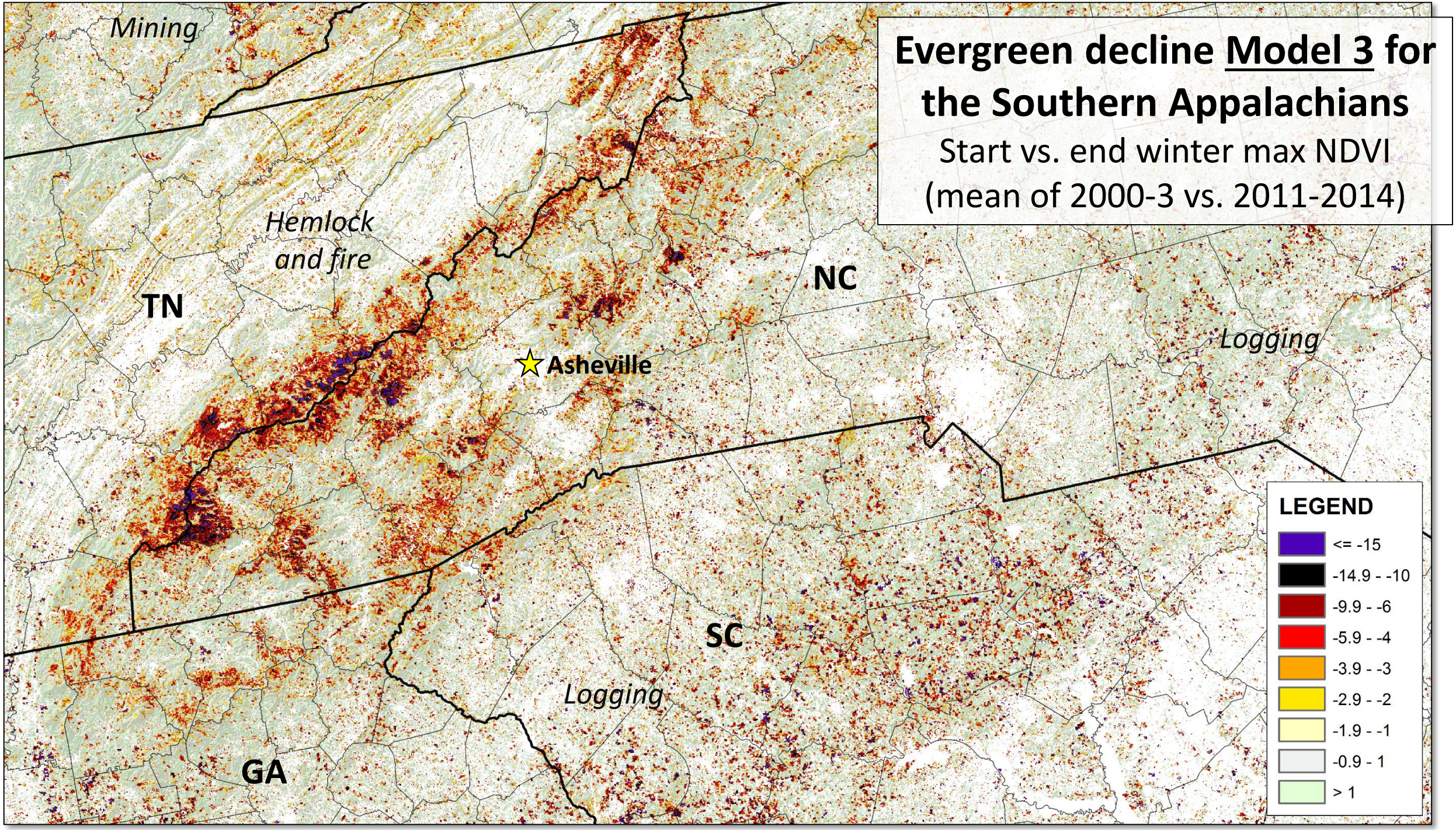
Evergreen decline Model 3 for the Southern Appalachians
Start vs. end winter max NDVI
(mean of 2000-3 vs. 2011-2014)
Mining
Hemlock and fire
TN
NC
Asheville
Logging
SC
Logging
GA
LEGEND
<= -15
-14.9 - -10
-9.9 - -6
-5.9 - -4
-3.9 - -3
-2.9 - -2
-1.9 - -1
-0.9 - 1
> 1

Summary

- Dormant season imagery successfully captures **evergreen decline** from hemlock woolly adelgid defoliation and mortality and other disturbances, but progressive decline is signature.
- With “coarse” (MODIS) and “moderate” (Landsat) resolution products, decline involves more than just canopy dead hemlock (is it understory dead?); this requires further examination.
- The pattern of decline across the Southern Appalachians is stunning. It involves both extensive forest patches and linear riparian-associated forms.
- Knowledge of where hemlock decline occurred can help address impacts and can provide reference conditions for restoration.